THE DIRECT METHANOL FUEL CELL PROSPECTS FOR COMMERCIALIZATION

GERALD HALPERT

ADVANCED TECHNOLOGY PROJECTS OFFICE

JET PROPULSION LABORATORY

PRESENTED AT

THE ROAD TO METHANOL FUEL CELL VEHICLES:

A NATIONAL FORUM

SPONSORED BY

AMI AND CMAI

WASHINGTON D.C.

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THE DIRECT METHANOL FUEL CELL
PROGRAM GOAL

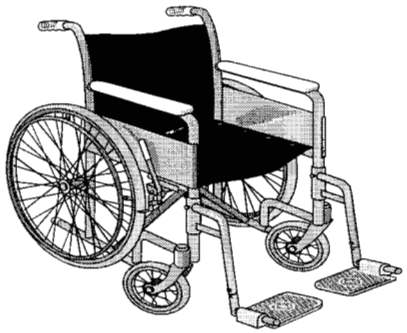
TO TRANSFER THIS TECHNOLOGY FROM THE *DEMONSTRATION* STAGE INTO THE COMMERCIAL MARKETPLACE

DIRECT METHANOL FUEL CELL SYSTEM ADVANTAGES

- **USE OF METHANOL AS A FUEL**
  - OFFERS HIGHER VOLUMETRIC ENERGY DENSITY THAN H_2 (5 KWH / L)
  - NO CO OR NO_x EMISSIONS - PRODUCES ONLY H_2O AND CO_2
  - PROVIDES CONVENIENT / RAPID FUEL DELIVERY / STORAGE
  - ELIMANATES HIGH PRESSURE H_2 / HYDRIDE STORAGE
- **DIRECT METHANOL OXIDATION REACTION**
  - ELIMINATES REFORMER - REDUCES COMPLEXITY
  - REDUCES WEIGHT AND VOLUME OF THE FUEL CELL SYSTEM
  - EXHIBITS MILLISECOND RESPONSE TO LOAD CHANGES
- **LIQUID FEED DESIGN RESULTS IN**
  - SIMLIFIED THERMAL MANAGEMENT AND CONTROLS
  - PREVENTION OF PROTON EXCHANGE MEMBRANE DRYOUT

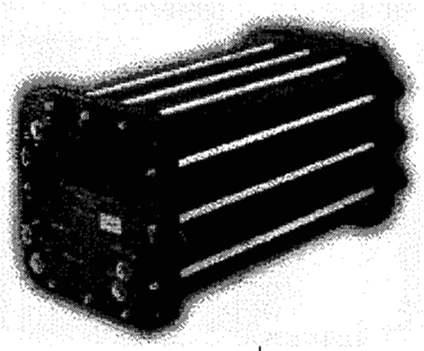
DMFC IS A PRACTICAL AND ATTRACTIVE ALTERNATIVE TO THE REFORMATE OR H_2 / AIR SYSTEM

TRANSPORTATION APPLICATIONS FOR THE DIRECT METHANOL FUEL CELL

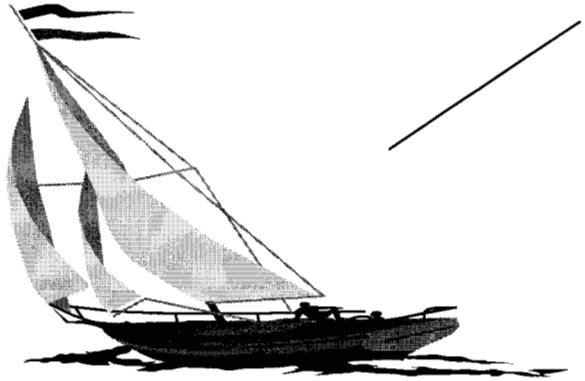


CO_2

Methanol
+
Air



POLUTION-FREE
POWER



Water

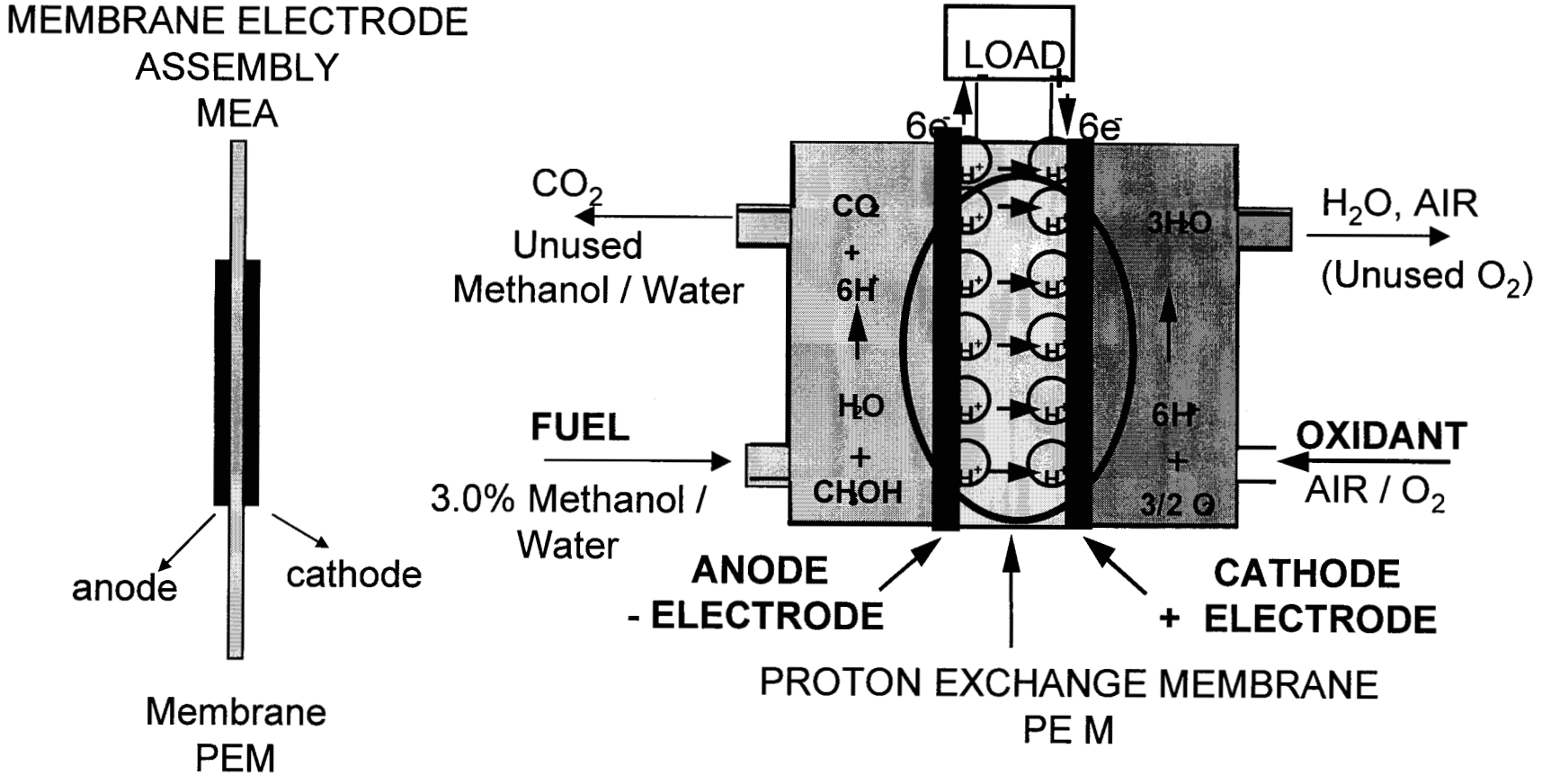
APPLICATIONS FOR THE DIRECT METHANOL, LIQUID-FEED FUEL CELL

NEAR TERM

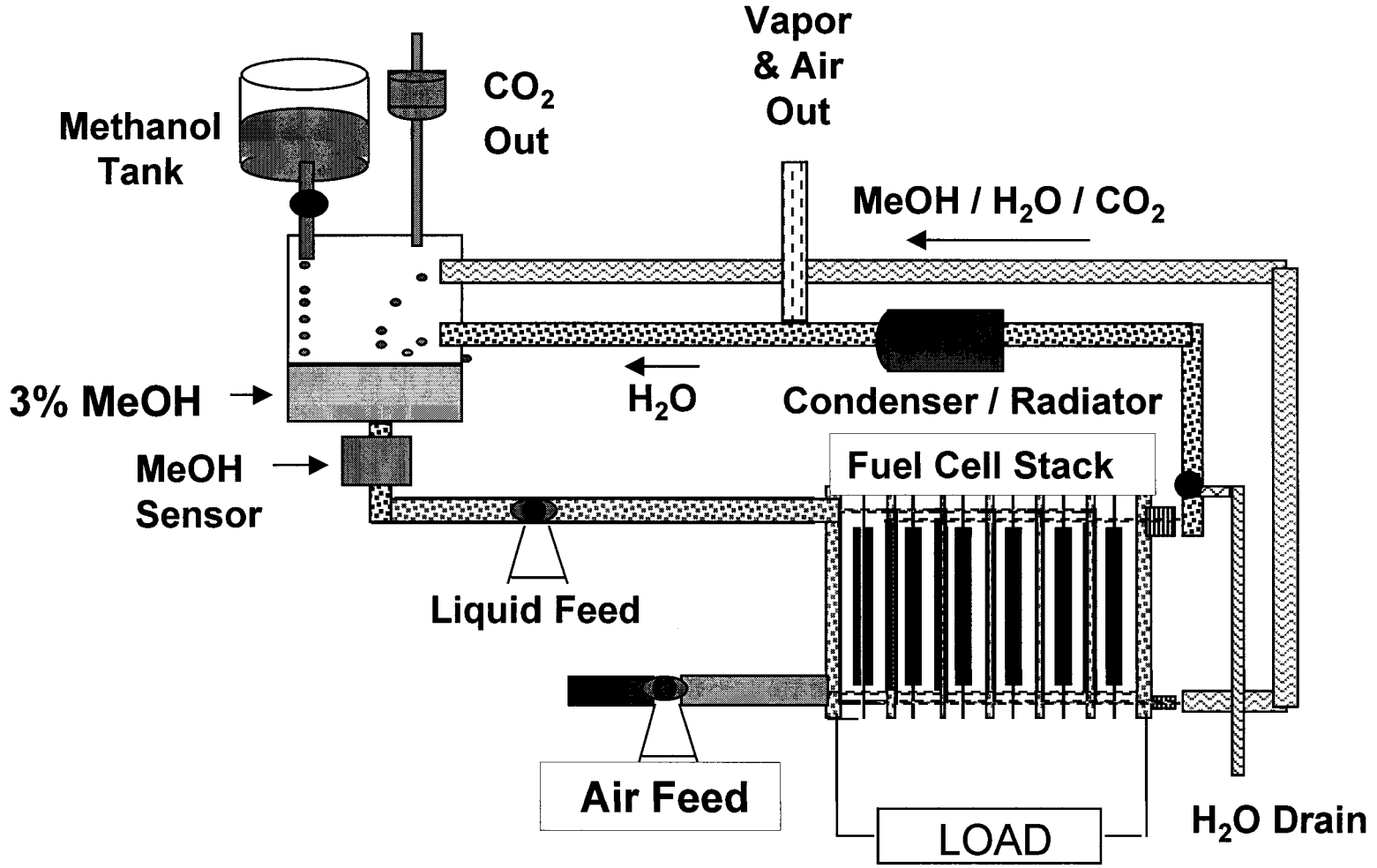
SAIL / POWER BOATS
EMERGENCY POWER
GOLF CARTS
PEOPLE MOVERS
AIRPORT VEHICLES
FACTORY TRUCKS
LAWN MOWERS

DIRECT METHANOL FUEL CELL VEHICLES

DIRECT METHANOL FUEL CELL SCHEMATIC



DIRECT METHANOL FUEL CELL SYSTEM CONCEPT



JPL DIRECT METHANOL FUEL CELL PROGRAMS

- **DEMONSTRATE A 150 W SYSTEM FOR DARPA**
  - **DEVELOP MATERIALS, STACKS, MEMBRANES AND SYSTEMS**
  - **50 W OPERATING SYSTEM DEMONSTRATED 4/97**
- **MATERIALS SELECTION / EVALUATION PREPARATION FOR UNIV. OF MINN. / ARMY RESEARCH OFFICE**
- **DEMONSTRATE A HYBRID FUEL CELL / BATTERY FIELD UNIT FOR ARMY FIELD APPLICATIONS**
- **DEVELOP A 1KW DEMO SYSTEM FOR CALIFORNIA**

COLLABORATORS

JET PROPULSION LABORATORY

CALIFORNIA INSTITUTE OF TECHNOLOGY

GINER INC.

H-POWER CO.

UNIVERSITY OF SOUTHERN CALIFORNIA

CARNEGIE MELLON UNIVERSITY

UNIVERSITY OF MINNESOTA

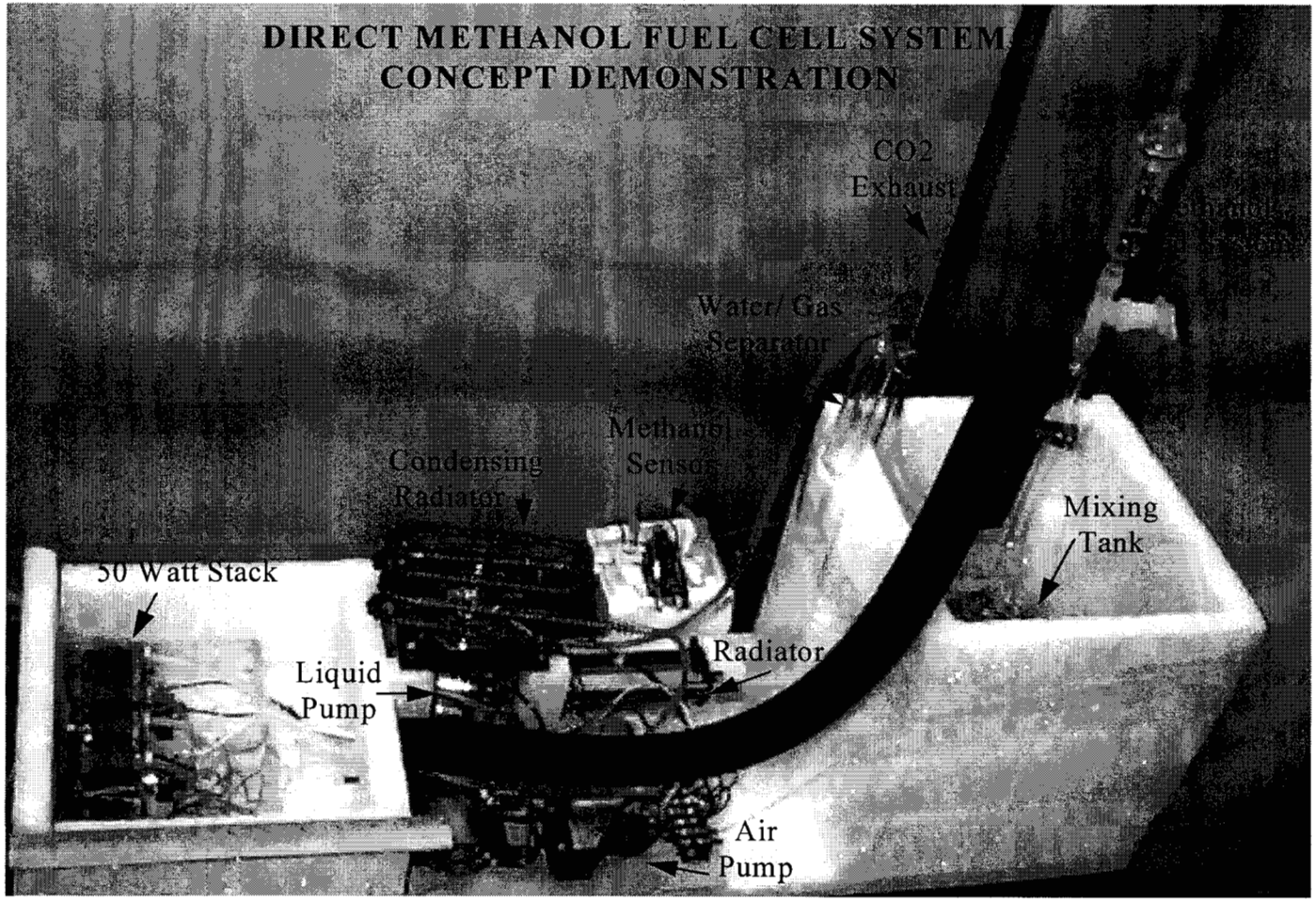
VALIDATION OF THE DIRECT METHANOL FUEL CELL TECHNOLOGY

- **200 HOURS OF CONTINUOUS STACK OPERATION AT 90 °C**
  No Noticeable Degradation
- **4500 HOURS OF INTERMITTENT STACK OPERATION AT 60°C**
  Minimal Loss in Power
- **CONTINUOUS SYSTEM OPERATION USING METHANOL SENSOR**
- **STABLE HIGH PERFORMANCE PT-RU CATALYSTS AND PROTON EXCHANGE MEMBRANE ASSEMBLIES**
- **ELECTROCHEMICAL AND THERMAL STABILITY DEMONSTRATED BY LOW CROSSOVER USC MEMBRANE**
  Up to 100°C in Limited Testing
- **DEMONSTRATED 34% EFFICIENCY OF METHANOL (>1.5 kWh/l) ON A STACK BASIS**

VALIDATION OF THE TECHNOLOGY

- **DIRECT METHANOL FUEL CELL CONCEPT DEMONSTRATED- 1992**
- **DEMONSTRATED PROMISING PERFORMANCE**
  - 34% STACK EFFICIENCY AT 90°C
    200 HOURS OF CONTINUOUS STACK OPERATION AT 90 °C
    No Noticeable Degradation
  - 4500 HOURS OF INTERMITTENT STACK OPERATION AT 60°C
    Minimal Loss in Power
- **DEVELOPED A NEW PROTON EXCHANGE (PEM) MEMBRANE**
  - REDUCES METHANOL CROSSOVER FROM 20 - 5%
  - IMPROVES METHANOL EFFICIENCY TO 45% (2KWH/L)
- **DEMONSTRATED FUEL CELL SYSTEMS**
  - 50W, HYBRID FIELD UNIT AND 150W SYSTEMS
- **WORK IN PROGRESS**
  - 1-5 KW SYSTEMS

FIRST DEMONSTRATION OF A DIRECT METHANOL 50 W FUEL CELL OPERATING SYSTEM



DIRECT METHANOL FUEL CELL / BATTERY HYBRID SYSTEM FOR ARMY FIELD USE

DMFC HYBRID SYSTEM

LI-ION BATTERY FOR PULSE POWER

DMFC FUEL CELL STACK FOR RECGHARGING

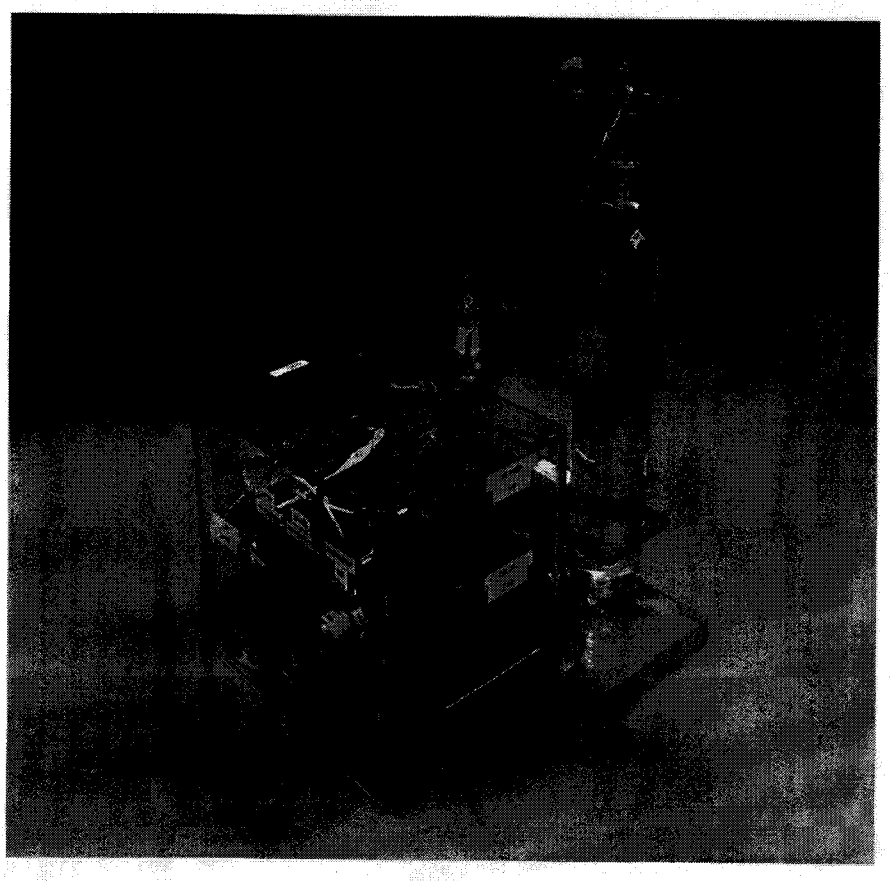
220 WH OVER FOR 6 MONTHS

PEAK POWER 5 A

MINUMUM STARTUP TIME

TEMPERATURE -32 TO 63°C

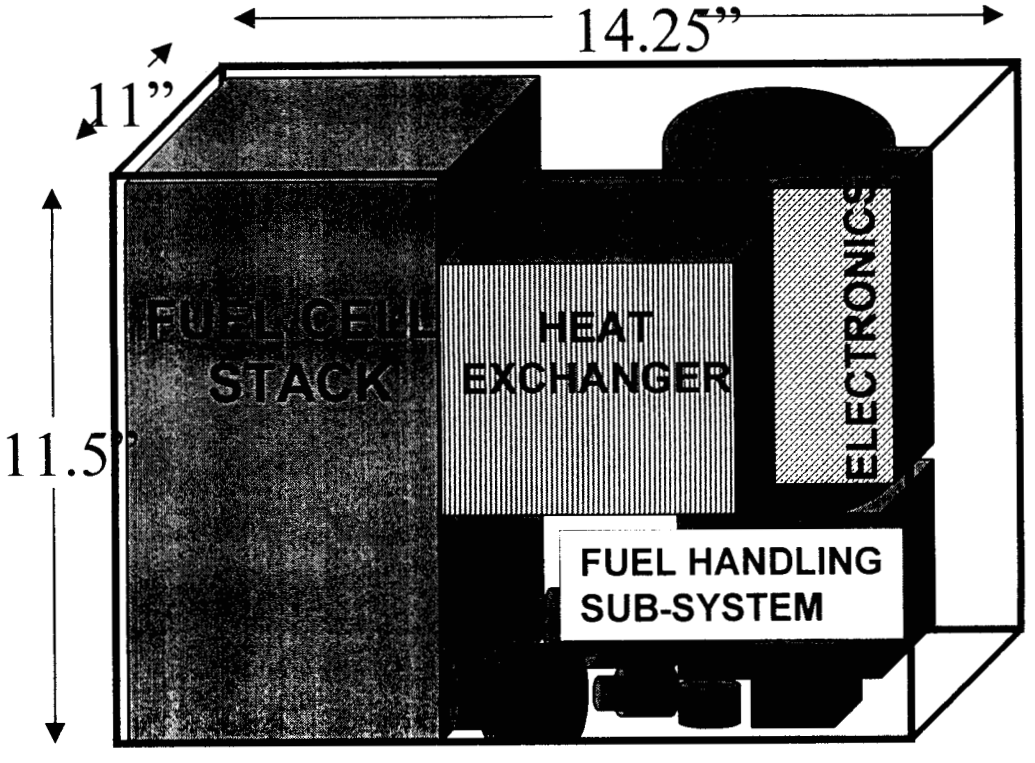
WATER / THERMAL BALANCE



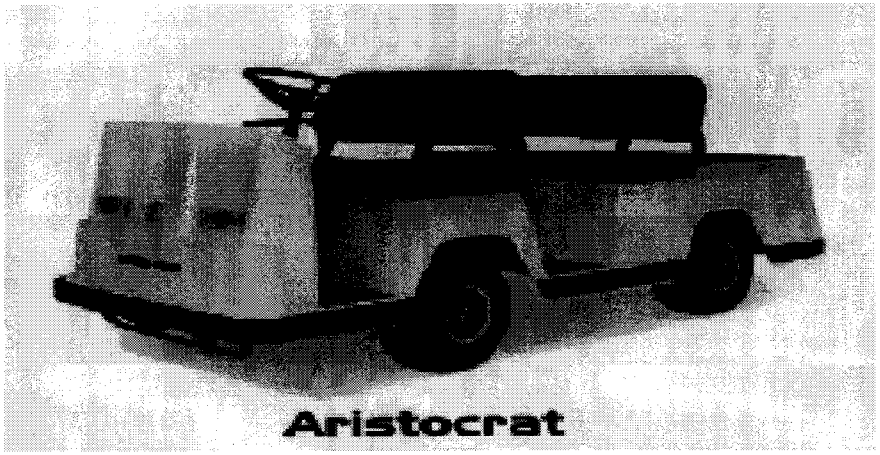
DIRECT METHANOL 150 W FUEL CELL BATTERY SYSTEM LAYOUT

BATTERY CHARGER

POWER	150 W
CAPACITY	5000 WH
VOLTAGE	24V
CURRENT	6.25A
MASS (W FUEL)	12 KG
VOL.	30 LITERS
OP. TEMP.	15-42^{O}C
START -UP	< 1 MIN.



DIRECT METHANOL 2.3 KW FUEL CELL SYSTEM IN A LIGHT DUTY VEHICLE APPLICATION



PEOPLE-MOVER	
LOAD CAPACITY	1600 LBS
BED VOLUME	253 LITERS
SYS. VOL.	80 LITERS
MASS	118 KG
MEOH TANK	10LITERS
ENERGY	12.3 KWH
CONT. OPER.	10 HRS

INTELLECTUAL PROPERTY STATUS

24 NEW TECHNOLOGY REPORTS

20 PATENT APPLICATIONS

3 ISSUED PATENTS

BASIC TECHNOLOGY PATENT

5,599,638

DIRECT METHANOL FUEL CELL CHALLENGES AND RESOLUTIONS

- **Methanol Crossover Reduces Performance**
  - Solution - USC Membrane Cuts Crossover From 20- 5%
- **Water Accumulation And Removal**
  - Solution - New Flow Fields & Materials Solve Problem
- **Stack Efficiency At 34%**
  - Solution - Stack Design, New Membrane, Increased Methanol Concentration Can Raise Efficiency To **45%**
- **Catalyst Preparation Is Time Consuming**
  - Solution - Engineering / Manufacturing Scale-Up Will Reduce Process Time

DIRECT METHANOL FUEL CELL CONCLUSIONS

- METHANOL FUEL CELLS HAVE APPLICATION OVER A WIDE POWER RANGE FROM LOW WATTS TO KILOWATTS
- METHANOL IS A CONVENIENT FUEL THAT IS EASY TO HANDLE AND STORE
- THE DIRECT METHANOL FUEL CELL SYSTEM IS LESS COMPLEX, AND EASIER TO REFUEL AND OPERATE THAN THE COMPETING TECHNOLOGY

A FINAL THOUGHT FOR YOUR CONSIDERATION

THE TECHNOLOGY IS READY

THE APPLICATIONS EXIST

THE ENVIRONMENT AWAITS

THE CHALLENGE IS FOR INDUSTRY TO MOVE IT INTO COMMERCIALIZATION